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ONSITE ENVIRONMENTAL SURVEILLANCE REPORT FOR THE INEL RADIOACTIVE WASTE MANAGEMENT COMPLEX ANNUAL REPORT — 1974

PREPARED BY AEROJET NUCLEAR COMPANY FOR
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
IDAHO OPERATIONS OFFICE UNDER CONTRACT E(10-1) -1375

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ONSITE ENVIRONMENTAL SURVEILLANCE REPORT

FOR THE INEL RADIOACTIVE WASTE MANAGEMENT COMPLEX

ANNUAL REPORT – 1974

by

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AEROJET NUCLEAR COMPANY

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I. PROGRAM DESCRIPTION AND RESULTS

I. INTRODUCTION

The Idaho National Engineering Laboratory (INEL) Radioactive Waste Management Complex (RWMC) is located in the southwest corner of the INEL as indicated in Figure 1. In turn, the INEL is located in the northwest section of the Snake River Plain in Eastern Idaho approximately 30 miles west of Idaho Falls.

This annual Onsite Environmental Surveillance Report for the INEL RWMC has been prepared to document the program conducted at the RWMC in 1974. The program is conducted in accordance with SWM-104 "Detailed Operating Procedures for the Environmental Surveillance Plan for the INEL Radioactive Waste Management Complex (RWMC)". This plan was prepared by Aerojet Nuclear Company (ANC) and approved by the Energy Research and Development Administration, Idaho Operations Office (ERDA-ID). Table I, "Environmental Surveillance Plan Summary", indicates the scope of this program.

Data and results in this report are restricted to those conditions existing at and within the perimeter of the RWMC. Measurements and reporting of conditions outside the perimeter of the RWMC are performed by ERDA-ID Health Services Laboratory (HSL).

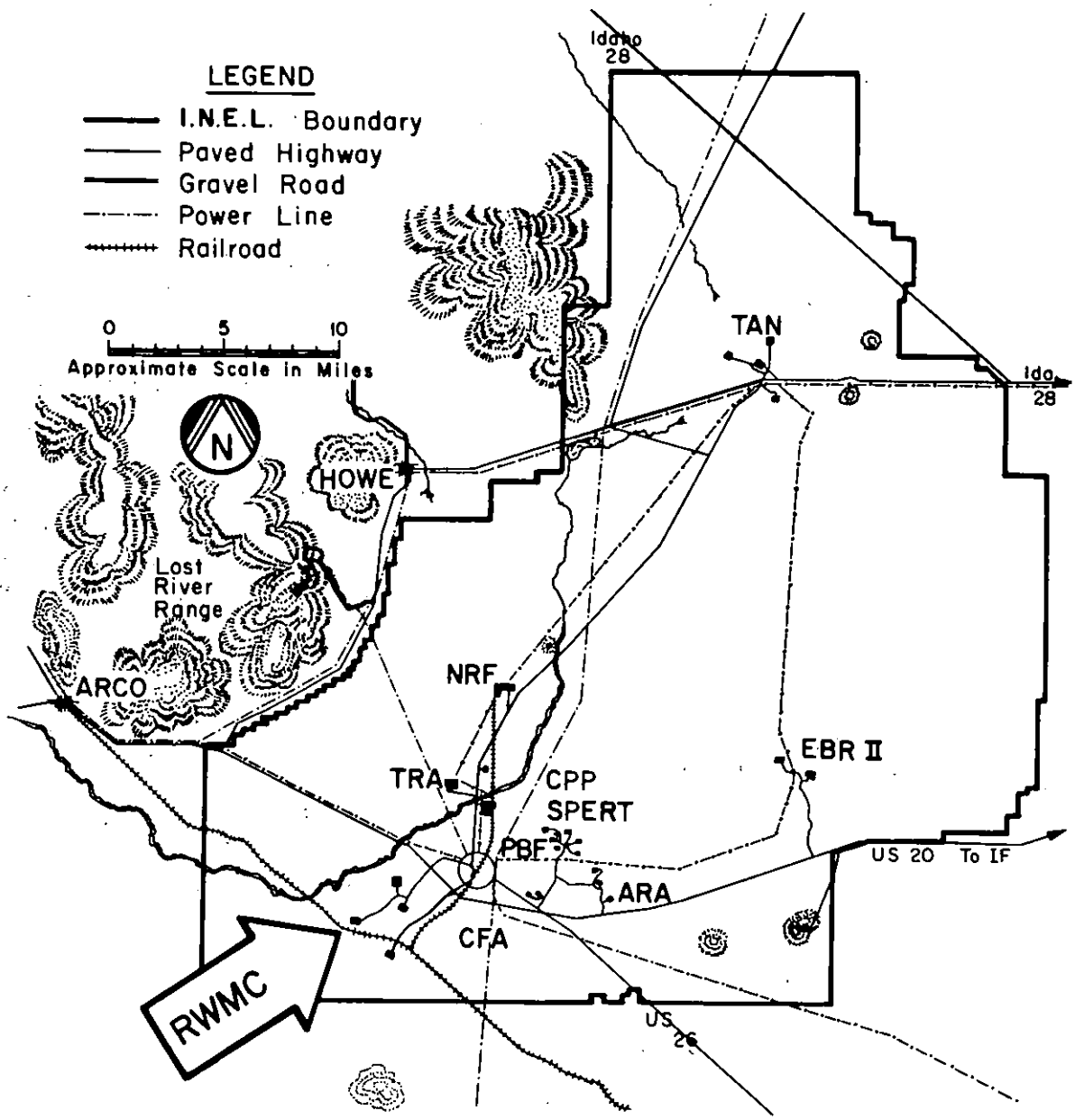

Fig. 1 RWMC location site.

TABLE I

ENVIRONMENTAL SURVEILLANCE PLAN SUMMARY

Sample Type	Description of Sampling Method	Sampling Frequency	Required No. of Samples	Analysis Procedure	Reporting Procedure
Gamma radiation background levels in the INEL RWMC and SL-1 Burial Ground	HSL 20-foot boom with 18 GM tubes	Annually	High reading recording in each 50-foot survey grid	Survey all areas within the INEL RWMC and SL-1 burial grounds	Survey results will be recorded on a grid survey map and compared with the results of the background survey completed in July 1973. Results will be reported in the annual Environmental Surveillance Report on the INEL RWMC
Soil Samples	Take surface, 15-cm and 30-cm samples at survey grid (150 foot) locations	Minimum of 25 samples annually taken at randomly selected locations in and near work areas and other selected areas	Minimum of 25 samples	Samples to be analyzed for plutonium and, in some cases, americium and a spectrum for major gamma emitters	Results to be reported in the annual Environmental Surveillance Report on the INEL RWMC
Air Samples	Low volume air samplers(~1 cfm)	RWMC perimeter - continuous sampling on the north and south sides and sampling of the pits and trenches during the day shift working hours	[a]	Long life beta-gamma and alpha determinations by Health Physics. Samples changed periodically by RWMC HP	Same as above
Water Samples Surface	Collect 500-ml samples in INEL stores standard 550-ml poly bottles	After periods of heavy rainfall or snow melting	Depends on the situation-sample TSA pad, Pad A, and any water that collects in pits	Send samples to ANC Radiation Measurements Lab, Reactor Technology Branch. Request analysis for major gamma and alpha emitters	Same as above
Moisture Probes Subsurface	Insert moisture probe to the bottom of the 33 sample holes at the RWMC and SL-1 Burial Ground	After spring thaw and in late fall before major frosts and other selected times	Thirty-three sample holes (26) INEL RWMC (7) SL-1 Burial Ground	Insert moisture probe to the bottom of each of the 33 sample holes, take a moisture content reading and record the reading	Same as above
Water Samples Subsurface	Collect 550 ml of water from sample holes if water is present	Same as above if water is found in the sample holes	Sample each hole which contains water	Send samples to ANC Radiation Measurements Lab, Reactor Technology Branch. Request analysis for major gamma and alpha emitters	Same as above
Sample 250-foot Well	Collect 550 ml of water from the well in a INEL stores standard 550-ml bottle (poly type)	Every 60 days	One sample each 60 days or every two months	Same as above	Same as above
Periodic Visual Inspections	Tour INEL RWMC and SL-1 Burial Ground visually inspect	Monthly	NA	Visually inspect the RWMC and SL-1 Burial Ground for areas that may have been exposed or other discrepancies. Log this inspection.	Same as above
Alpha Contamination Survey on Soil Surface with Plutonium X-Ray Monitor	Walking with X-Ray monitor	Initial survey on entire RWMC and then annually in and around work-disturbed areas	NA	Walk over survey recording readings at preselected intervals	Same as above

[a] Air Samples — A minimum of three samplers will be operated continuously on the north side of the RWMC and three air samples operated continuously on the south side of the RWMC.

Portable beta gamma monitors will be operated during working hours on north-northeast and south-southwest sides of the pit work area and the trench work area. An alpha air monitor will be operated continuously on the TSA pad and on Pad A.

2. RADIATION LEVELS

The annual RWMC radiation level survey was conducted in August and September 1974, using HSL's truck mounted 20-foot boom. Results of this survey, Figure 2, indicated several areas where radiation levels exceeded 1 mR/hr at 3 feet above ground surface.

In particular, higher than normal radiation readings were noted near trenches 57, 55, and 15 and near pit 13. Subsequent to this survey, these areas and all other areas above 1 mR/hr at 3 feet were covered with soil to bring radiation levels to less than 1 mR/hr at 3 feet above surface grade. This is in accordance with SWM-104.

HSL conducts a perimeter radiation monitoring program at the RWMC utilizing thermoluminescent dosimeters (TLDs). Figure 3 locates the TLD monitoring sites and indicates HSL's identification system. The TLD monitoring during this reporting period began in November 1973 and continued through November 1974, with a midperiod monitor change being made in early May 1974. Integrated results are reported in Table II.

Figure 3 indicates, besides TLD monitoring sites, the relative locations of burial trenches 57 and 58. Trench 57 was used during 1974 until mid-June; trench 58 was in use from February 20, 1974 through the rest of 1974. Figures 4 and 5 are plots of integrated 6-month TLD exposures, as measured by HSL over a 2-year period beginning in November 1972. Figure 4 is plots of monitoring sites near trench 57, and Figure 5 is plots of monitoring sites near trench 58.

Perimeter monitoring sites near trench 58 show a definite increase of exposure beginning with the period of the use of trench 58. Sites near trench 57, on the other hand, show a marked decrease in exposure between April and November of 1974. This is indicative of the termination of the use of trench 57 in June 1974.

Data shown in Figure 4 reveal one apparent incongruous result. Site 35 shows an unexpected large increase in exposure in the October 1974 reading. The sites 31 and 33, immediately to the south of BG-35, and sites 1 and 3, immediately to the north of BG-35, all show a very sharp decrease between the April 1974 reading and the October 1974 reading. In fact, of all 18 TLD monitoring sites, all show a decrease between these readings except for BG-35. The use of trenches 57 and 58 in 1974 and the trend in all other TLD monitoring sites therefore make the result obtained from BG-35 monitoring site difficult to explain, unless it is assumed that the reading is incorrect. A review of the data presented in Figure 2 would support this conclusion; both this survey shown in Figure 2 and an April 1974 survey indicate that the highest readings present at the perimeter of the RWMC were in the vicinity of monitoring station BG-33 and, therefore, if any significant increases were to be expected they would be at this station. Such was not the case.

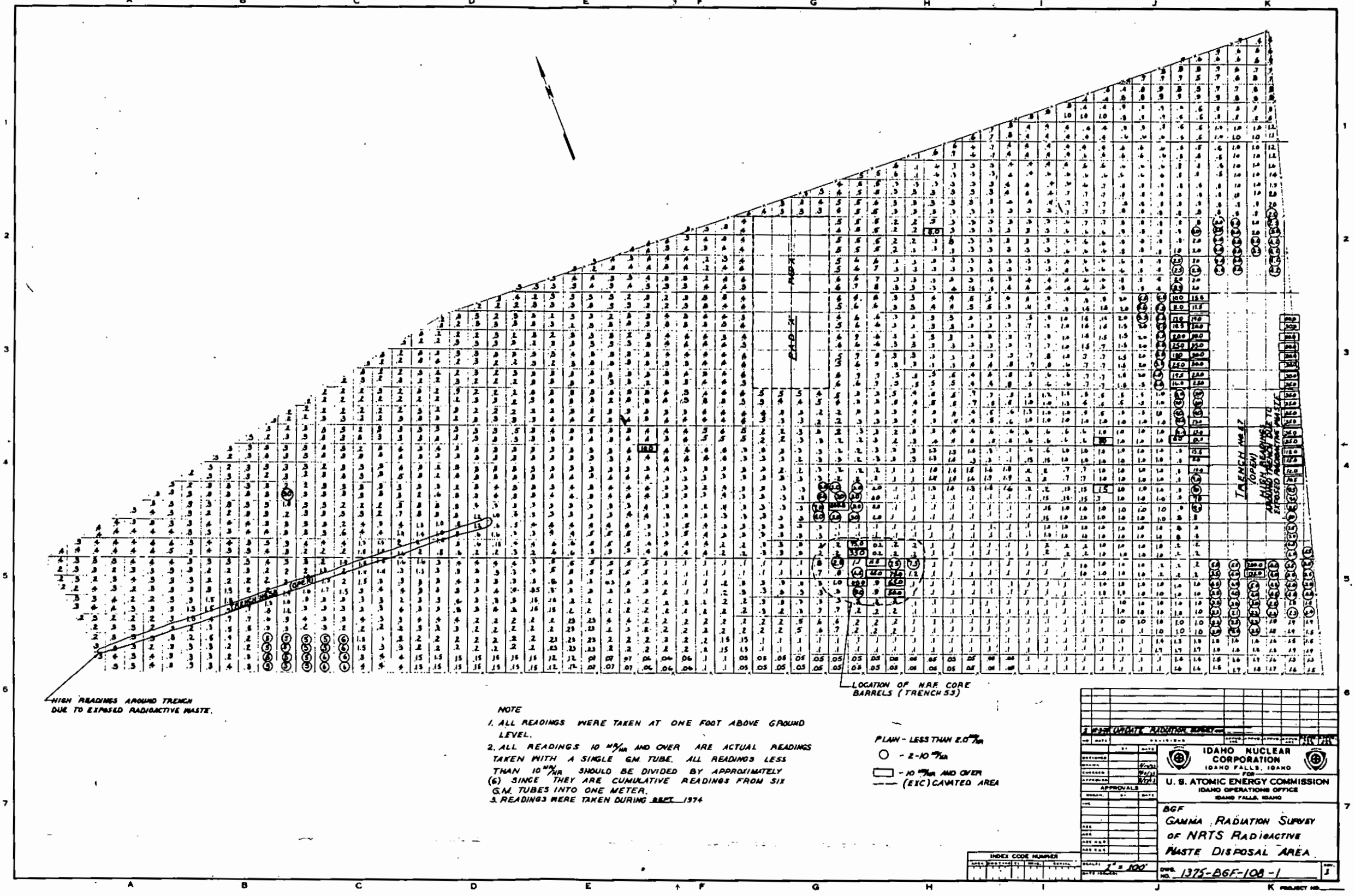

Fig. 2 Radiation survey 1974.

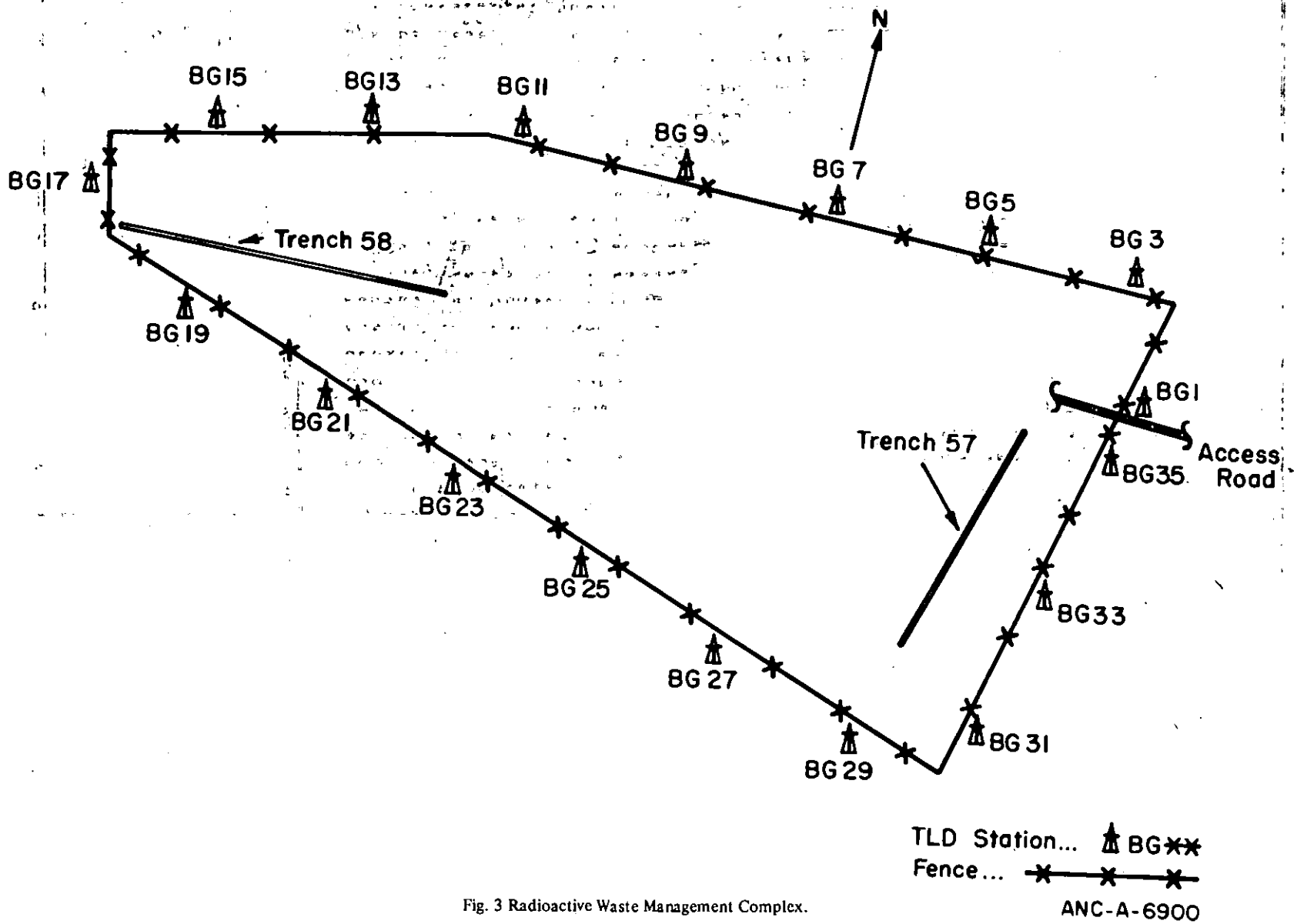

Fig. 3 Radioactive Waste Management Complex.

TABLE II

PERIMETER RWMC INTEGRATED RADIATION LEVELS FROM NOVEMBER 1973 THROUGH NOVEMBER 1974 AS REPORTED BY HSL

TLD Station	Adjusted Six-Month Exposure, mR 11/73 - 4/74	5/74 - 10/74
1	1,890	900
3	800	290
5	760	330
7	390	270
9	280	250
11	310	200
13	420	200
15	310	130
17	210	110
19	430	160
21	990	400
23	490	360
25	440	410
27	1,030	650
29	5,050	1,580
31	7,360	1,780
33	16,800	3,520
35	3,250	11,900

3. SOIL SAMPLES

In late spring 1973, 160 locations within the Radioactive Waste Management Complex were sampled according to a square grid with 150-foot separations. Three samples were taken at each location – one at the surface, one at a 15-centimeter depth, and one at a 30-centimeter depth. The surface samples were analyzed by commercial laboratories, with quality control being maintained by including spiked pseudosamples with actual samples. A detailed report of the results of this survey is attached (Appendix A). Results from this analysis were not received until 1974 and 1975.

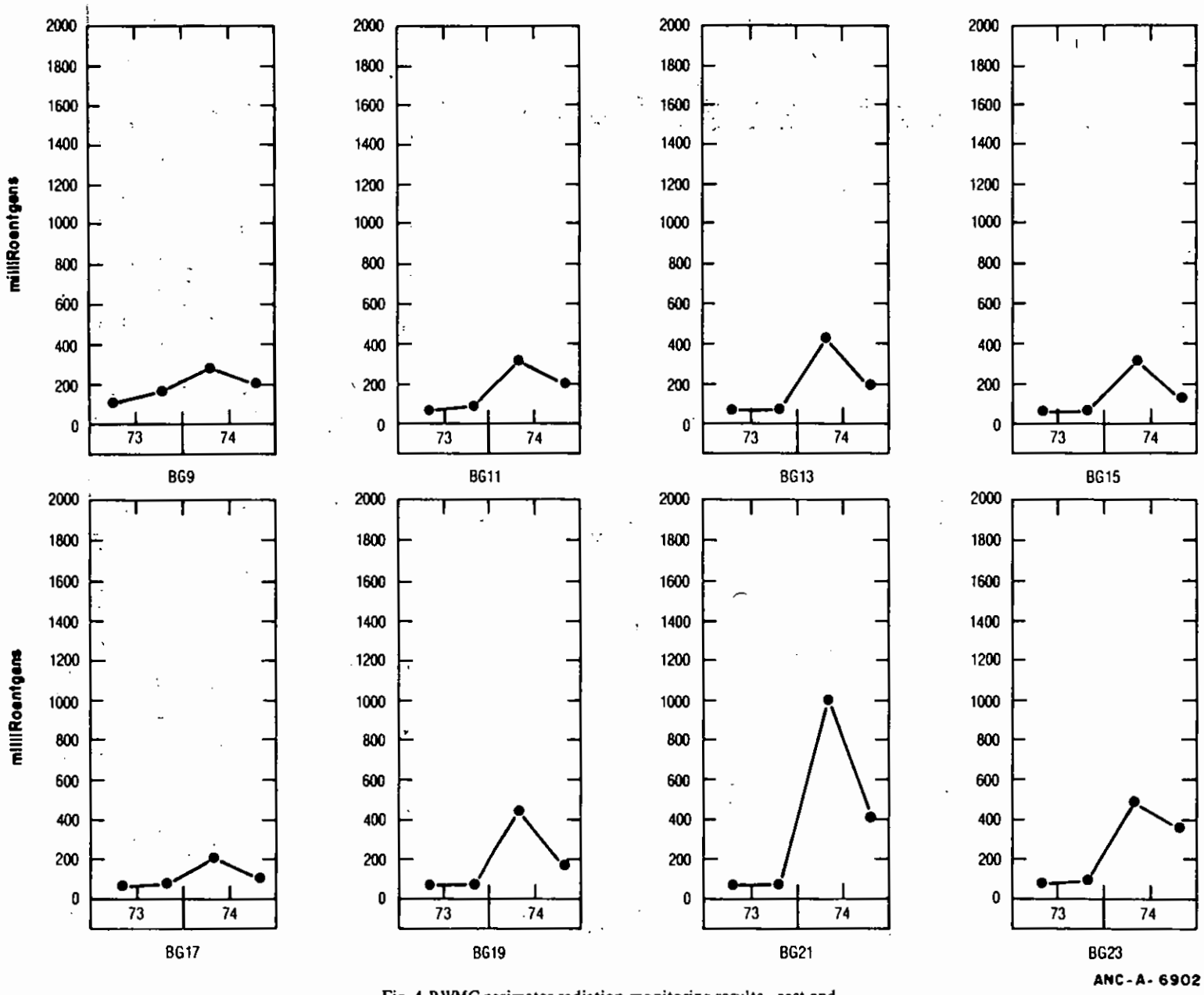

Fig. 4 RWMC perimeter radiation monitoring results - east end.

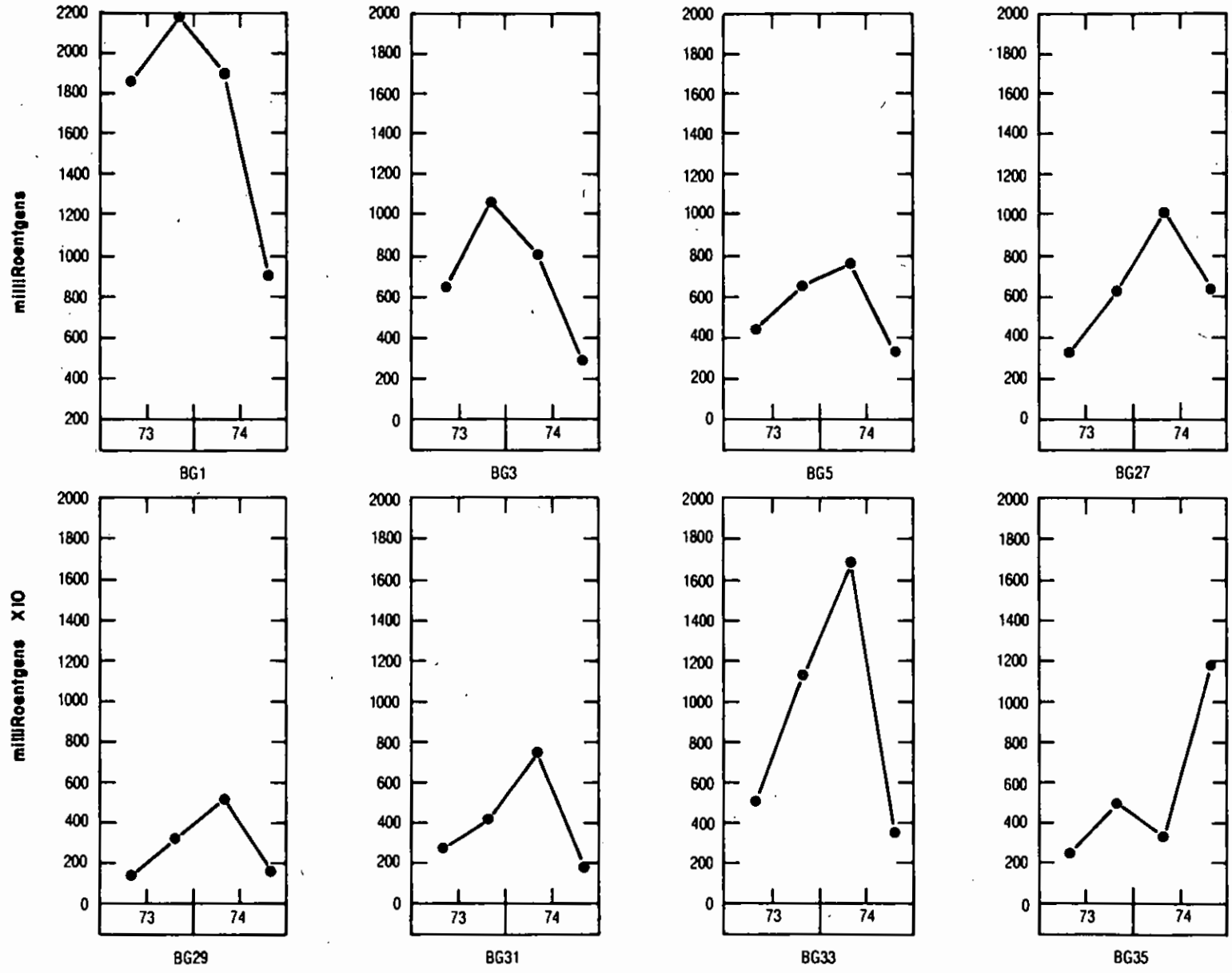

Fig. 5 RWMC perimeter radiation monitoring results - west end.

ANC-A-6901

Figure A-1 of Appendix A shows plutonium-239 concentration isopleths based on these data. It would indicate seven possible locations, labeled A-G on Figure A-1, where possible plutonium contamination could be originating. These locations are:

Designation	Site Description
A	NE Corner, Pit 2
B	SE Corner, Pit 3
C	Center, Pit 6
D	East Side, Pit 5
E	Open Area
F	Open Area
G	Open Area

Location E-G because of being in open and unused areas would be probable surface contamination sites. Their probable sources would be:

(1) Flood. Prior to installation of the present flood control system, localized heavy drainage could and did occasionally occur at the Radioactive Waste Management Complex, such as in 1959, 1961, and particularly in 1962. General land slope at this facility is from southwest to northeast. The pattern of isopleths in Figure A-1 would support a general carrying of contamination from the general vicinity of pit 3 by water flow.

(2) Wind. Predominate wind at the RWMC is from the southwest direction. Thus, any surface contamination which might be present would be resuspended by both surface winds and localized activity and show a resulting spreading to the northeast. The pattern of isopleths in Figure A-1 could also support a general carrying of contamination from the general vicinity of pit 3 by surface winds.

In December 1974 40 additional surface samples were collected at 100-foot intervals (100-foot intervals were selected for finer detail) and sent to a commercial laboratory for plutonium-239 analysis. The results of this survey are shown in Tables B-I, -II, and -III of Appendix B. Of the 40 samples, 4 were spiked pseudosamples, 10 were in or near the Initial Drum Retrieval (IDR) air support structure, and 26 were from the RWMC general area. The sampling was of insufficient size to provide any definite conclusions or to affirm or negate 1973 data. General area results are shown in Figure B-I of Appendix B. Figure B-2 of Appendix B shows the results of the air support structure survey.

Although, as stated in the previous paragraph, the sample size was too small to provide conclusive verification or negation of 1973 sampling results, the results seem to indicate that elevated surface contamination levels do indeed exist near the pit 3 area, with lower elevated levels being present in the northeast corner of the RWMC. A tenuous conclusion may also be hypothesized that a northeast movement of surface contamination is observable by comparison of 1973 and 1974 data. This would be in keeping with the previously advanced supposition that prevailing winds at the RWMC would tend to cause surface contamination to migrate in the northeast direction.

The foregoing statements will be resolved when pertinent 15- and 30-centimeter samples obtained in 1973 are analyzed and when further and more comprehensive surface analyses are made.

Based on 1973 data, it is calculated (see Appendix A) that the top 2.5 centimeters of soil at the RWMC contains an average plutonium concentration of 4.98 disintegrations per minute per gram of soil. Accordingly, the plutonium inventory in the top 2.5 centimeters of soil at the RWMC is 13.7 millicuries. The maximum reported 1973 soil activity was 81.9 disintegrations per minute per gram (d/m/g). Maximum 1974 soil activity reported was 115 d/m/g. In comparison, worldwide fallout for plutonium averages 0.1 to 0.3 d/m/g of surface soil. The variability of the distribution of plutonium at the RWMC is great; for instance, 12 sample sites within the RWMC indicate that 7.5% of the RWMC area contains approximately 67% of the plutonium present in the top 2.5 centimeters of soil within the confines of the RWMC. This result if not surprising in view of the concentrated locations of transuranic storage within the RWMC.

No health physics problem currently exists within the RWMC due to these low levels of surface plutonium contamination. This is because plutonium, being an alpha emitter, presents a negligible external hazard and because the levels are so low that, if resuspended in air, the internal hazard due to inhalation would be insignificant. For instance, for a large area contaminated with 4.98 d/m/g of Pu-239, a resuspension factor of 1×10^{-6} meters^{-1}, and a soil density of 1.2 grams per cubic centimeter, calculated airborne Pu-239 activity is 1.87×10^{-14} μCi/cc. Maximum permitted Pu-239 airborne activity in a restricted area – such as the RWMC – is 2×10^{-12} μCi/cc. Therefore, it can be seen that the low level surface contamination existing presents no airborne and, hence, internal hazard. Even at levels of 115 d/m/g (a factor of 23.1 above the average of 4.98 d/m/g) the calculated airborne activity is only 4.32×10^{-13} μCi/cc, still only 21.6% of the allowable level.

4. AIR SAMPLES

A continuous air sampling program did not begin at the RWMC until January 1975. This was due to the facts that commercial power was not available until December 1974 and that the cost of purchase of an electrical generator to supply necessary power was judged excessive. Therefore, the initiation of the continuous air monitoring program was delayed until such time as commercial power became available by direction of ERDA.

In January 1975, six especially designed continuous air monitors were set into operation at the perimeter of the RWMC.

During 1974 numerous operational air samples were taken by ANC Health Physics around various waste disposal operations where potential airborne radioactivity could have existed. No excessive airborne contamination levels were found; all gross alpha results were less than 1×10^{-13} μCi/cc, which is significantly less than the most restrictive allowable Pu-239 air activity of 2×10^{-12} μCi/cc in a restricted area. The majority of measured alpha activities in air samples fell between 1×10^{-14} and 5×10^{-14} μCi/cc.

5. WATER SAMPLES – SURFACE

After significant rainfall or snow melting, approximately 540 milliliter samples of precipitation runoff are collected at the Transuranic Storage Area (TSA) and the Transuranic Disposal Area (TDA). The samples are then analyzed by Aerojet Nuclear Company's Radiation Measurements Laboratory.

Samples collected, with results, are documented in Table III.

TABLE III

SURFACE WATER SAMPLE RESULTS -- 1974

Sample Date	Sample Location	Sample Volume (ml)	Counting Minutes	Results (μCi/ml)
8-7-74	TDA (Pad A)	550	60	background
	TSA	540	60	Cs-137: $8.1 \pm 2.3 \times 10^{-7}$
8-29-74	TSA	540	60	Cs-137: $6.8 \pm 3.2 \times 10^{-7}$
10-9-74	TDA (Pad A)	486	30	background
	TSA	440	30	background
10-22-74	TDA (Pad A)	540	30	background
	TSA	540	30	background
10-30-74	TDA (Pad A)	540	30	background
	TSA	540	30	background
12-4-74	TDA (Pad A)	540	30	background
	TSA	540	30	background

As shown, only two samples indicated any radionuclide activity in excess of background. The TSA samples of August 7, 1974 and August 29, 1974 indicated low-level cesium-137 activities of $8.1 \pm 3 \times 10^{-7}$ μCi/ml and $6.8 \pm 3.2 \times 10^{-7}$ μCi/ml, respectively. These levels are far below ERDAM-0524 and 10CFR20 limits of 4×10^{-4} μCi/ml of Cs-137 in restricted areas. In fact, these measured levels are significantly less than the unrestricted limit for Cs-137 of 2×10^{-5} μCi/ml. Therefore, it may be concluded that no hazard existed in 1974 due to surface waterborne radionuclides.

6. WATER SAMPLES – SUBSURFACE

This phase of the program is carried out by the United States Geological Survey (USGS). Moisture probes were taken in April 1974, July 1974, and again in December 1974 of all the shallow holes (26 main BG-7SL-1) drilled to bedrock in the RWMC and the SL-1 burial site. Comparison of this information revealed no significant differences in the moisture content of the holes between April, July, and December; none of the holes contained any free liquid water.

Frequent sampling of the 213.5-foot well (well 92) inside the RWMC is no longer performed because of the extreme caution necessary to assure that contamination is not introduced into the well through the sampling procedure.

Water level measurements were made in well 92, located inside the INEL Subsurface Disposal Area (SDA), on a semimonthly basis. The well is 213.5 feet deep. The water level rose 0.7 foot from the first of 1974 until May 29, 1974. A water sample collection from the well on May 29, 1974 caused the water level to drop 1.2 feet. The water level then rose 0.9 feet in the last seven months of the year. The water level was 208.0 feet below the land surface at the end of the year.

The water sample from well 92 contained $2.5 \pm 0.8 \times 10^{-7}$ μCi/ml Pu-239 and -240, no detectable H-3, Sr-90, or gamma emitters. The specific conductance of the water was 690 micromhos. Plutonium detected in the well is thought to have resulted from contamination of the well during the sampling operation.

Levels of Pu-239 and -240 found are far below the ERDAM-0524 limits of 1×10^{-4} μCi/ml of either Pu-239 or -240 in a restricted area and, in fact, are well below the unrestricted area limits of 5×10^{-6} μCi/ml. Accordingly, no hazard is presented by the levels of plutonium noted in the same.

7. PERIODIC VISUAL INSPECTIONS

Inspection tours were made each month over the INEL RWMC and over SL-1 SDA by a member of the RWMC Operations Branch and an HP technician. The areas were visually inspected for sunken spots, exposed waste, bad fences, missing or illegible signs, and general discrepancies. Discrepancies were corrected when found.

Through 1974 several holes and sunken spots were found and covered. Pit 2 area was identified as having only a thin covering of soil. Efforts are being initiated to add an additional foot of soil cover to the area over that pit. Pit 2 is shown in Figure A-2.

8. STORAGE CELL MONITORING

Work was initiated during FY-74 on monitoring of the environment inside the TSA cells for humidity, temperature, and radioactivity. Actual measurements began in September. The purpose of this monitoring is to determine existing cell conditions in order to estimate the store life of the waste containers. The measurements may be useful in quantifying transfer of heat and water vapor across the soil cover of the TSA.

The equipment includes two Foxboro 12-channel recorders mounted in a trailer on the covered TSA stack. One recorder receives temperatures from the soil surface and from each of four drum layers within the cell. Only very small temperature differences exist among different elevations in a cell.

The second recorder receives dew point temperatures from the cell and the outside air near the soil. Foxboro dew cells attached to probes are inserted into closed cells at multiple plan locations and into multiple layers of drums in order to get an overall perspective of cell conditions. Very little difference in dew point occurs among locations and layers inside a storage cell.

Cell temperature trends may be observed in this manner, and cell relative humidity may be calculated using these data. Cell 6, a summer-closed cell, had a dew point range of 22 to 36^{o}F and a temperature range of 48 to 62^{o}F. Cell 5, a cell closed in the winter, showed a dew point range of 32 to 50^{o}F and temperatures of 48 to 62^{o}F.

From data obtained to date, it appears that the cell affords very good insulating qualities. Only very small temperature fluctuations are shown by the data. Moisture transferred to the cell from the atmosphere or vice versa is hardly detectable.

APPENDIX A

PLUTONIUM IN SURFACE SOIL

OF THE

SUBSURFACE DISPOSAL AREA

APPENDIX A

PLUTONIUM IN SURFACE SOIL

OF THE

SUBSURFACE DISPOSAL AREA

1. SUMMARY

In May and June 1973, 160 sites were sampled in an 88-acre area; 111 showed statistically significant plutonium content. Average plutonium activity is 5.0 disintegrations per minute per gram of surface soil (d/m/g). (Local background due to weapons fallout is in the range of 0.1 to 0.3 d/m/g in surface soils.) Maximum value was 6.2 d/m/g in surface soil. Inventory of Pu in the top 2.5 cm of soil is 13.7 millicuries. All average values and inventory are ± 20%. The distribution pattern suggests several distinct sources of the plutonium, the most important being the south end of pit 3 and pit 5 (see Figure A-1). Contamination levels in directions in downwind from (apparent) source areas drop off sharply with distance, suggesting that winds have not seriously mobilized the contamination. No serious health physics problems are indicated.

The results suggest several points that deserve further study. These include search for the Pu source(s) near the southern boundary of the RWMC; identification of places where plutonium occurs at depth in contrast to dispersion on the surface; and studies to show the importance of distributional details not resolved by the sample spacing used in the present study.

Pu concentrations in SDA soils are equivocal, and future studies will likewise be equivocal. The objectives of soil sampling in the future should be limited to what the data can be expected to resolve. Division objectives and limitations should be established for this matter.

2. PROCEDURE

2.1 Sampling

Sites were established on a square grid with separations of 150 feet (Fig. A-2). A volume of soil 10 cm square by 2.5 cm deep (in situ) comprised a sample. Samples were taken from the surface and at depths of 15 and 30 cm. Only the surface samples are described in this report. Samples were taken with a special scoop 10 cm wide to help control geometry during sampling. The scoop was cleaned between uses to avoid cross-contamination. Samples at depth were taken after preparing a hole which gave room to

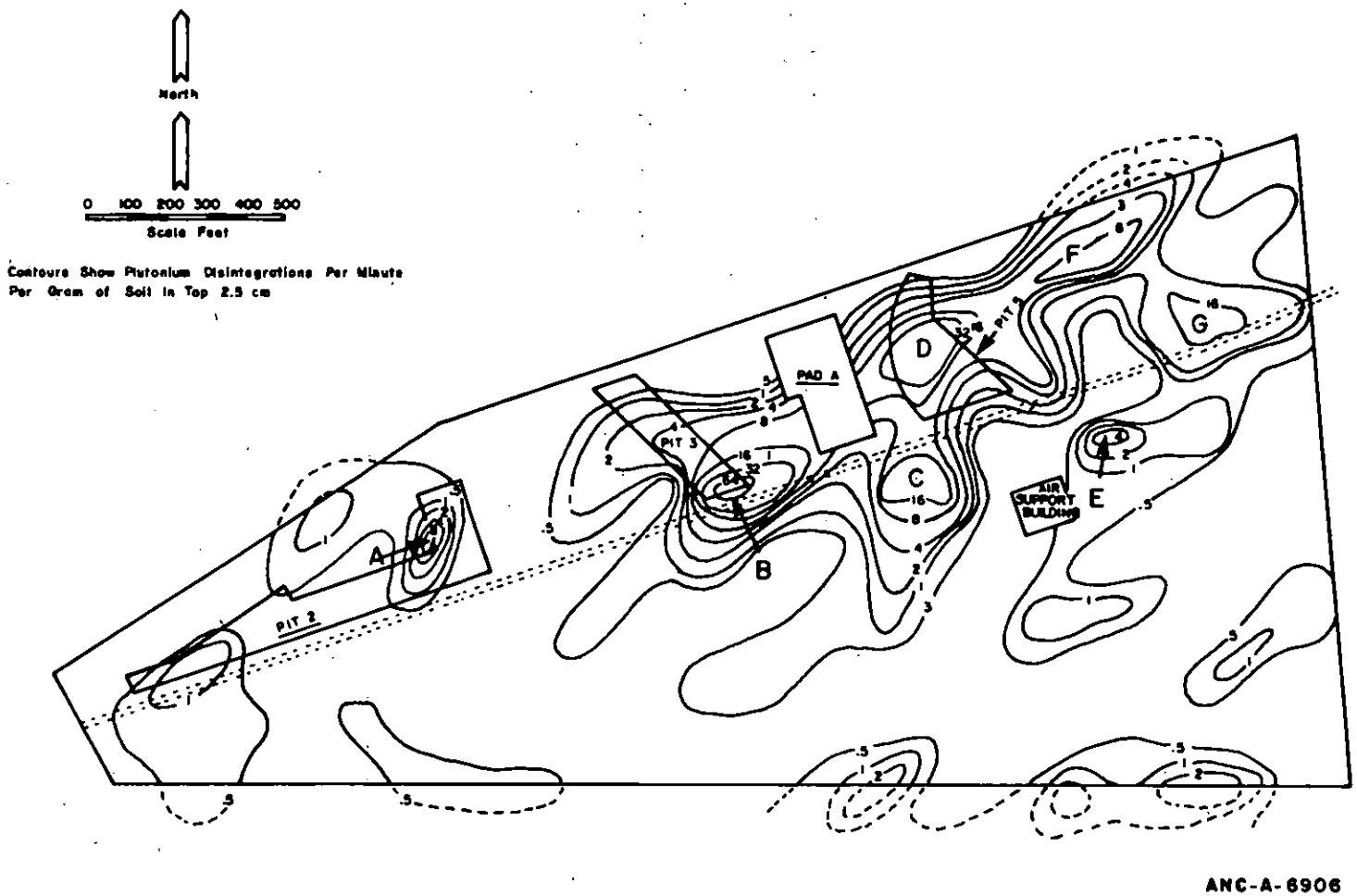

Fig. A-1 Plutonium isopleths.

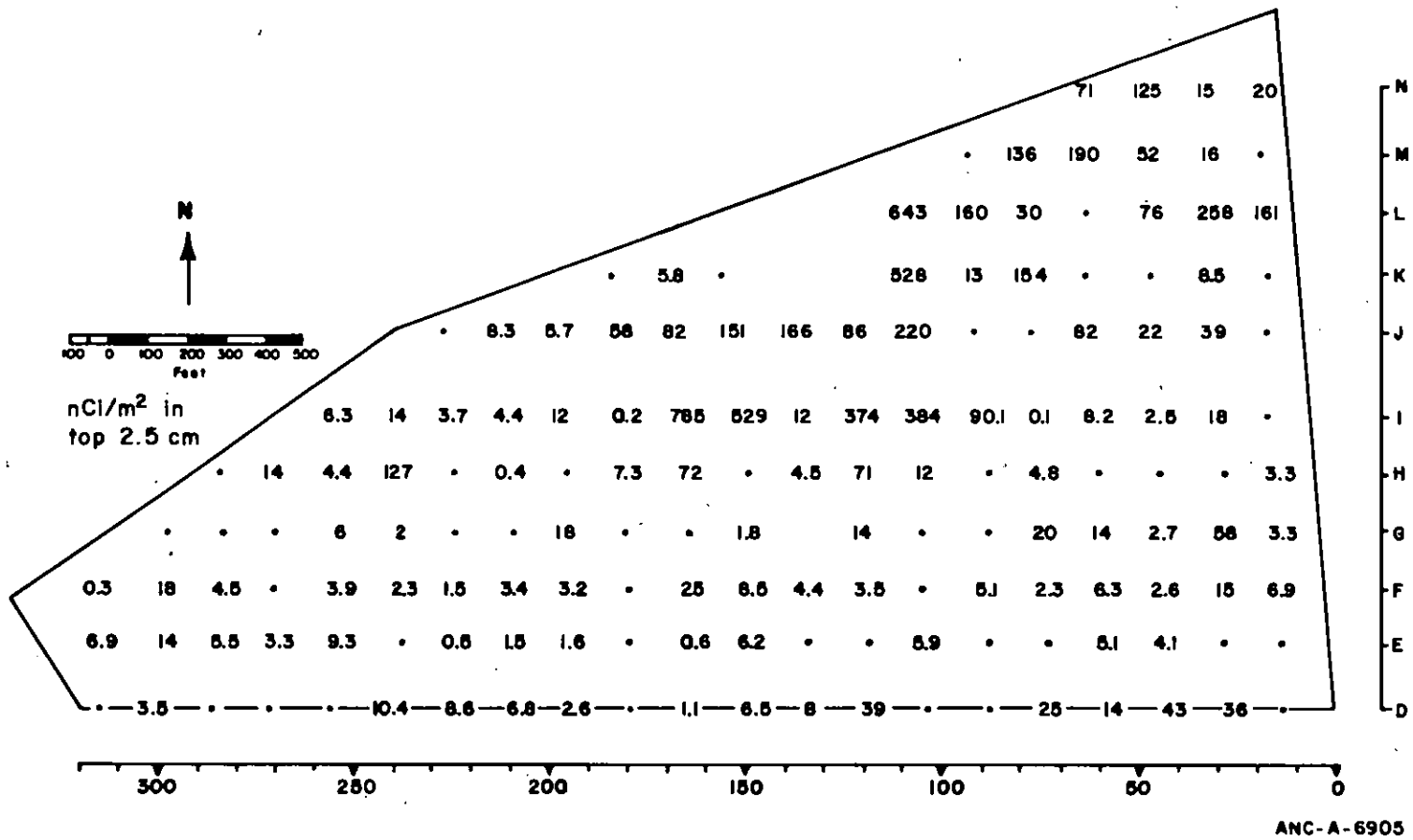

Fig. A-2 Sample locations and Plutonium concentrations.

maneuver the scoop at the chosen depth. Soil samples were immediately put into polyethylene bags which were then sealed and marked with a location number, depth, and date.

2.2 Sample Preparation

Larger pieces of organic debris were picked by hand from the samples which were then dried in open pans for two to three hours at 120°C. After cooling, clods were broken with mortar and pestle while avoiding the grinding of single mineral fragments. Samples were then divided into two fractions with a sieve (No. 35 U.S. Standard, 500 micrometer opening). Both fractions were weighed; the fine fraction was saved for chemical analysis; and the coarse was discarded.

2.3 Analysis

Ten-gram aliquots were analyzed by dissolution in hydrofluoric acid (Lab A) or by pyrosulfate fusion (Lab B), making chemical purification of the plutonium, electrodepositing on a planchette, and counting by alpha spectrometry. Chemical recovery was traced, with spikes of Pu-236 added to each sample before dissolution.

2.4 Quality Control

Standard samples were included in all batches of samples sent to Laboratories A and B. These provide a measure of bias between the separate laboratories and the source of the standards, the ERDA Health Services Laboratory (HSL). The calculated biases are used later to adjust reported values to conform better with what the HSL might have obtained had they done all the analytical work.

Thirty-eight standard samples were analyzed in all, but only 14 were used for estimating bias. These 14 were selected because they were analyzed by the same analytical procedures used for the bulk of the actual samples. The performance on the standards is shown in Table A-I. Preparatory standards run by Lab A were involved with the first batch and on subsequent effort. Busts concern substantial analytical values that appear statistically unrelated to the analytical variance indicated by "usable" category. "Usable" concerns standards (including blanks) for which performance appears statistically homogeneous. Blanks were considered missed if the reported value was 0.1 dpm/g or greater. True value for blanks is less than 0.01 dpm/g. Further evaluation of performance on standards is shown in Table A-II.

2.5 Adjustments

Before raw analytical data are plotted in map form, several adjustments must be made, namely, to account for:

(1) Bias compared to a reference laboratory

TABLE A-I

STANDARDS

Outcome	Lab A	Lab B
Preparatory	15	8
Blanks correct[a]	2	1
Blanks incorrect[a]	0	1
Busts	1	0
Usable[a]	5	5
Totals	23	15

[a] Used in adjusting for bias.

(2) Inflation due to analysis of only part of the whole soil

(3) Deflation due to Pu in the discarded fractions of whole soil

(4) Conversions from d/m/g to nanocuries per square meter (nCi/m^2).

For these data, bias was estimated by a method of linear regression involving a least squares fit between "usable" values for standard samples reported by Lab A (or B) and the standard values supplied by HSL. The adjustment for bias was made by changing the reported value (dpm/g) according to the fitted regression. This adjustment resulted in an increase of about 22% for most nonzero value from both labs, but small values were affected much more than 20% (Table A-III).

Adjustment for inflation was made after adjustment for bias. A multiplier computed for each sample, equal to the ratio of weights of fine grained fraction to whole soil, was applied to (adjusted) dpm/g values. These factors ranged from 0.48 to 0.89, averaging 0.67.

Adjustment for deflation was the multiplier 1.05 applied to all samples. No data are available for estimating an accurate value for this adjustment. The value used corresponds to about 5% of the Pu in the whole soil being discarded with the coarse fraction.

Conversion of units from dpm/g to nCi/m^2 involves the area of the sample (100 cm^2), the relation 2,200 dpm = nCi, and the weights of the samples (whole soil) which ranged from 166 to 363 g, averaging 260 g.. The above factors are related according to:

$$nCi/m^2 = dpm/g\ (W)\ (0.0454\ nCi/dpm)$$

where

W = weight of the whole soil sample in grams.

TABLE A-II

PERFORMANCE ON STANDARDS

Lab A (dpm/g)	HSL (dpm/g)	Fitted	% Malfit Before	% Malfit After
0.0	0.007			
25.9	31.4	30.69	-18	-2.3
0.61	0.529	0.44	+15	-17
13.0	14.9	15.26	-13	+2.4
0.0	0.007			
9.03	8.98	10.51	+1	+17
0.26	0.527	0.02	-51	-96
Weighted average malfit			-13.6	+1.01

Linear regression

HSL = 1.196A - 0.289

Fitted = 1.196(Reported) - 0.289

Coefficient of determination is 0.996

Lab B (dpm/g)	HSL (dpm/g)	Fitted	% Malfit Before	% Malfit After
9.13	15.0	11.40	-39	-24
0.346	0.776	0.566	-55	-27
0.579	0.535	0.853	+8.2	+60
0.121	0.007	0.29		
12.88	13.5	16.0	-4.6	+19
0.077	0.007	0.23		
0.703	0.535	1.01	+31	+88
Weighted average malfit			-22	-1.5

HSL = 1.233B + 0.139

Fitted = 1.233(Reported)+ 0.139

Coefficient of determination is 0.928

TABLE A-III

PLUTONIUM DATA AND ADJUSTMENTS

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
D 15	A	0.0	0.0	0.664	237	–	–
30	B	2.81	3.60	0.712	299	2.69	36.5
45	B	2.75	3.53	0.888	286	3.29	42.7
60	B	1.13	1.53	0.649	291	1.04	13.8
75	B	2.18	2.83	0.704	260	2.09	24.7
90	A	0.0	0.0	0.635	217	–	–
105	A	0.0	0.0	0.715	247	–	–
120	B	3.75	4.76	0.732	235	3.66	39.0
135	B	0.71	1.01	0.658	257	0.70	8.1
150	B	0.36	0.58	0.796	294	0.48	6.5
165	B	0.21	0.40	0.891	239	0.37	4.1
180	A	0.0	0.0	0.614	270	–	–
195	B	0.30	0.51	0.454	238	0.24	2.6
210	B	0.80	1.13	0.560	225	0.66	6.8
225	B	0.82	1.15	0.592	265	0.71	8.6
240	B	0.73	1.04	0.868	242	0.95	10.4
255	A	0.0	0.0	0.725	232	–	–
270	A	0.03	0.0	0.558	235	–	–
285	A	0.06	0.0	0.680	290	–	–

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
300	A	0.46	0.26	0.836	337	0.23	3.5
315	A	0.16	0.0	0.577	237	-	-
E 15	A	0.0	0.0	0.660	222	-	-
30	A	0.04	0.0	0.594	239	-	-
45	B	0.31	0.52	0.639	258	0.35	4.1
60	B	0.41	0.64	0.621	267	0.42	5.1
75	A	0.24	0.0	0.703	220	-	-
90	A	0.0	0.0	0.632	210	-	-
105	B	0.42	0.66	0.647	288	0.45	5.9
120	A	0.0	0.0	0.642	298	-	-
135	A	0.04	0.0	0.484	241	-	-
150	B	0.51	0.77	0.617	276	0.50	6.2
165	A	0.29	0.06	0.708	290	0.04	0.6
180	A	0.0	0.0	0.603	270	-	-
195	B	0.05	0.20	0.647	260	0.14	1.6
210	B	0.06	0.21	0.633	233	0.14	1.5
225	A	0.29	0.06	0.702	246	0.04	0.5
240	A	0.0	0.0	0.675	258	-	-
255	B	0.76	1.08	0.658	275	0.75	9.3

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
E 270	B	0.22	0.41	0.633	270	0.27	3.3
285	A	0.76	0.62	0.757	244	0.49	5.5
300	B	1.04	1.42	0.741	272	1.10	13.6
315	B	0.69	0.99	0.684	215	0.71	6.9
F 15	A	0.69	0.54	0.820	325	0.46	6.9
30	B	1.88	2.46	0.427	297	1.10	14.9
45	B	0.24	0.44	0.547	230	0.25	2.6
60	A	0.82	0.69	0.692	275	0.30	6.3
75	B	0.20	0.39	0.603	207	0.25	2.3
90	B	0.54	0.81	0.511	257	0.43	5.1
105	A	0.0	0.0	0.609	194	-	-
120	B	0.26	0.46	0.592	272	0.29	3.5
135	B	0.33	0.55	0.724	234	0.42	4.4
150	B	0.45	1.31	0.658	206	0.91	8.5
165	A	2.88	3.16	0.708	233	2.34	24.8
180	B	0.0	0.0	0.694	216	-	-
195	B	0.33	0.55	0.712	171	0.41	3.2
210	B	0.43	0.67	0.637	166	0.45	3.4
225	A	0.45	0.25	0.711	180	0.19	1.5

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
F 240	B	0.08	0.24	0.694	286	0.17	2.3
255	B	0.31	0.52	0.665	236	0.36	3.9
270	A	0.0	0.0	0.621	260	-	-
285	B	0.25	0.45	0.639	328	0.30	4.5
300	B	1.94	2.53	0.654	233	1.74	18.4
315	A	0.27	0.03	0.699	281	0.02	0.3
G 15	B	0.25	0.45	0.634	244	0.30	3.3
30	B	0.44	0.68	0.766	223	0.55	5.8
45	A	0.60	0.43	0.757	171	0.34	2.7
60	A	1.58	1.60	0.730	244	1.23	13.6
75	B	2.00	2.60	0.654	242	1.79	19.6
90	A	0.01	0.0	0.663	237	-	-
105	A	0.0	0.0	0.652	258	-	-
120	A	2.09	2.21	0.673	196	1.56	13.9
150	A	0.42	0.21	0.699	261	0.15	1.8
165	A	0.14	0.0	0.652	237	-	-
180	A	0.0	0.0	0.607	216	-	-
195	A	1.87	1.95	0.667	285	1.37	17.7
210	A	0.12	0.0	0.532	237	-	-

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
G 225	A	0.0	0.0	0.763	298	-	-
240	A	0.40	0.19	0.739	294	0.15	2.0
255	B	0.37	0.60	0.730	289	0.46	6.0
270	A	0.0	0.0	0.729	223	-	-
285	A	0.14	0.0	0.776	301	-	-
300	A	0.0	0.0	0.713	261	-	-
H 15	B	0.17	0.35	0.726	273	0.27	3.3
20	A	0.15	0.0	0.667	278	-	-
45	A	0.12	0.0	0.692	335	-	-
60	A	0.0	0.0	0.579	259	-	-
75	A	0.75	0.61	0.596	279	0.38	4.8
90	A	0.03	0.0	0.685	262	-	-
105	B	1.08	1.47	0.657	265	1.01	12.2
120	A	8.18	9.50	0.532	295	5.31	71.1
135	A	0.72	0.57	0.602	275	0.36	4.5
150	A	0.0	0.0	0.774	251	-	-
165	A	5.10	5.81	0.720	363	4.39	72.4
180	A	1.04	0.96	0.574	278	0.58	7.3
195	A	0.14	0.0	0.643	268	-	-
210	A	0.29	0.06	0.646	196	0.04	0.4
225	A	0.12	0.0	0.738	205	-	-

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
H 240	B	8.68	10.8	0.745	330	8.45	127.0
255	B	0.26	0.46	0.773	260	0.37	4.4
270	B	0.93	1.29	0.801	287	1.08	14.1
285	A	0.24	0.0	0.627	263	-	-
I 15	A	0.0	0.0	0.750	217	-	-
30	B	2.00	2.60	0.624	234	1.70	18.1
45	A	0.48	0.29	0.685	260	0.21	2.5
60	B	0.67	0.97	0.670	264	0.68	8.2
75	A	0.26	0.02	0.524	258	0.01	0.1
90	A	1.15	1.09	0.698	251	0.80	9.1
105	B	36.4	45.0	0.467	383	22.1	384.0
120	B	34.7	42.9	0.651	281	29.3	374.0
135	A	1.21	1.16	0.668	331	0.81	12.2
150	B	60.7	75.0	0.578	256	45.5	529.0
165	B	81.9	101.0	0.582	280	61.7	785.0
180	A	0.27	0.03	0.698	170	0.02	0.2
195	A	1.34	1.31	0.679	271	0.93	11.5
210	B	0.24	0.44	0.860	244	0.40	4.4
225	B	0.15	0.32	0.750	320	0.25	3.7

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
I 240	B	0.93	1.29	0.691	333	0.94	14.2
255	A	0.77	0.63	0.704	299	0.47	6.3
J 20	A	0.0	0.0	0.576	265	-	-
35	B	3.59	4.57	0.635	282	3.05	39.0
50	B	1.86	2.43	0.692	279	1.77	22.4
65	A	7.42	8.59	0.674	297	6.08	82.0
80	A	0.0	0.0	0.710	268	-	-
95	A	0.0	0.0	0.534	239	-	-
110	A	18.1	21.4	0.727	296	16.3	220.0
125	B	6.42	8.05	0.777	288	6.57	85.9
140	B	11.9	14.8	0.831	284	12.91	166.0
155	B	11.8	14.7	0.734	293	11.3	151.0
170	B	7.00	8.77	0.736	269	6.78	82.3
185	A	4.19	4.72	0.810	307	4.01	56.0
200	B	0.57	0.84	0.822	174	0.73	5.7
215	B	0.46	0.71	0.617	300	0.46	6.3
K 20	A	0.0	0.0	0.540	270	-	-
35	A	1.10	1.03	0.637	273	0.69	8.5
50	A	0.0	0.0	0.499	200	-	-

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g/)	Fine (fraction)	Whole Soil (grams)	Whole Soil (dpm/g)	nCi/m^2
K 65	A	0.0	0.0	0.638	231	-	-
80	B	14.0	17.4	0.695	267	12.7	154.0
95	A	1.80	1.86	0.672	216	1.31	12.9
110	B	42.7	52.8	0.755	278	41.9	528.0
155	A	0.0	0.0	0.748	267	-	-
170	B	0.32	0.53	0.858	268	0.48	5.8
L 20	A	13.6	16.0	0.747	282	12.6	161.0
35	B	20.2	25.0	0.822	263	21.6	258.0
50	A	7.69	8.91	0.829	217	7.76	76.4
65	A	0.0	0.0	0.742	227	-	-
80	A	3.88	4.35	0.635	233	2.90	30.1
95	B	16.3	20.2	0.689	239	14.6	159.0
110	B	56.8	70.2	0.706	272	52.0	643.0
M 20	A	0.0	0.0	0.705	334	-	-
35	A	1.41	1.40	0.783	302	1.15	15.8
50	B	5.73	7.20	0.663	229	5.01	52.1
65	B	21.6	26.8	0.699	224	18.7	190.0
80	B	14.8	18.4	0.696	222	13.4	136.0
95	A	0.0	0.0	0.697	281	-	-

TABLE A-III (contd.)

Location	Lab	Reported (dpm/g)	Fitted (d/m/g)	Fine (fraction)	Whole Soil Grams	Whole Soil (dpm/g)	nCi/m^2
N 20	B	1.28	1.72	0.825	303	1.49	20.5
35	B	0.94	1.30	0.709	340	0.97	14.9
50	B	11.9	14.8	0.670	264	10.4	125.0
65	B	6.42	8.05	0.697	267	5.89	71.4
Geometric average, $\overline{X}g$							12.35
Standard Geometric Deviation, SGD							6.01
Arithmetic averages, $\overline{X}a$							
Numerical				0.671	259.6		38.87
Calculated from $\overline{X}g$ and SGD						4.98	61.67

3. RESULTS

Basic data and computed values are tabulated in Table A-III. The values for nCi/m^2 were plotted as a map; isopleths were drawn among the plotted values (Figure A-1).

3.1 Plutonium Distribution

Most of the Pu activity is in the northern third of the disposal area. Highest concentrations appear near the southeast end of pit 3 and in the general area of pit 5. Subsidiary highs occur elsewhere but not always in conjunction with pit areas. Presumably, some of these subsidiary highs are superficial in the soil and result from the movement of contamination from a true site to the surface of another site. Analysis of selected samples from depths of 15 and/or 30 cm could identify superficial anomalies.

The anomalous values near the southern boundary of the RWMC do not appear connected with high zones elsewhere. Since no transuranic wastes (TRU) have been intentionally buried in trenches near the south boundary, further study there should be done.

The major trend of the distributional pattern aligns with about NE by E, essentially the same as the net wind (at Central Facilities Area) which blows toward N 60^{o}E. Secondary trends lie on several other vectors, some at right angles to the major trend. Concentration gradients across the disposal area tend to be steep. Since adjacent isopleths differ from one another by a constant factor (of 2), uniform spacing of isopleths indicates exponential changes in concentration. Evidence of counter trends and steep gradients suggests that winds have not been seriously active in dispersing available plutonium.

3.2 Health Considerations

Maximum concentrations for whole soil are near 60 dpm/g and near 100 dpm/g for the fine fraction (less than 500 μm) analyzed. These levels do not constitute a serious health hazard either to visitors or employees[a].

3.3 Limits to Interpretation

Limitations to the use of these data may be serious since the sample spacing appears to be large compared to lateral extent of some details in the distributional pattern. In several places, the Pu concentrations change 50-fold within one sampling interval. Although prominent sequences of high and low values are encountered, as for instance along the main access road, the data are barely adequate to substantiate the detail which appears in the isoplethal map (Figure A-1). Probably, much more detail exists in fact than appears in Figure A-1, but its resolution (substantiation) would require additional sampling.

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[a] For example, a worker's inhalation of dusty air could be controlled for the quartz content [the threshold limit value (TLV) is 570 micrograms of suspended soil per cubic meter of air]. Seventy-five years continuous exposure would be required for a person to inhale also 16 nCi of Pu (a maximum permissible lung burden) on dusts contaminated by 100 dpm/g if the dusts infected the air at the TLV of 570 $\mu g/m^3$.

A technical issue, which no information in this study addresses, concerns the sampling variance: how well the 2100 sq. meters of area involved with one site are actually represented by the sample of 0.01 sq. meter. The problem is particularly troublesome for the area of this study because of disturbance regularly caused by heavy equipment. Not only is soil mixed in irregular ways, but also the sites have risked being scraped or filled prior to sampling but after a contaminating event. Although the majority of values for Pu concentration are undoubtedly fair, an unknown, but possibly substantial, fraction of the values are seriously nonrepresentative of the area to which they are assigned. Adjacent values give some clues about the believability of "suspected" samples, but their reliability is also uncertain since some extreme variability is undoubtedly real.

For subsequent studies that utilize these data, the variability in space is confounded with variability in time due to agitation of the soil or by new releases. One is tempted to use sets of soil samples taken at intervals of time to indicate whether contaminating incidents have taken place. That approach is theoretically correct, but equivocal and often unrewarding in practice. The great variability across space requires many samples for its resolution, and changes of Pu concentration due to rearrangement of soil at a site are statistically difficult to distinguish from new increments of contamination. If new contamination were redistributed by disturbance of the soil, soil sampling would need to be very intense in order to assess even simple facts about the matter.

4. RECOMMENDATIONS

The present set of data provides a basis for deciding what kind of future utility might be obtained by (routine) soil sampling and at what cost. Clear objectives of soil sampling at the Radioactive Waste Management Complex should be coordinated with the limitations on interpreting data imposed by the current (and expected) status of contamination.

Regardless of what routine sampling program is pursued, this present study points to two items that should be resolved: distribution of Pu with depth in the soil and identification of source for Pu near the southern boundary. Since samples at depths of 15 and 30 cm were collected (in May and June 1973), one needs only to select some for analysis. The purpose of analyzing samples from depth lies not only in identifying superficial contamination on the surface apart from contamination extended at depth but also in finding contamination at depth in places covered with noncontaminated soil. Thus, samples from depth selected for analysis should come from areas that appear "barren" on the surface as well as from places with substantial surface contamination.

Identifying the source of contamination at the south boundary could be started by analysis of deeper samples already taken there. A few new surface samples could be taken to verify the reality of the contamination already indicated.

APPENDIX B

PLUTONIUM IN SURFACE SOIL

OF THE

RADIOACTIVE WASTE MANAGEMENT COMPLEX

APPENDIX-B

TABLE B-I

SOIL SAMPLE RESULTS

1974

PLUTONIUM-239 AND -240

Location		Result (dpm Per Gram of Soil)
KL	10	0.762 ± 0.056
	20	7.332 ± 0.415
	30	0.372 ± 0.037
	40	0.535 ± 0.038
	50	0.454 ± 0.043
	60	0.956 ± 0.050
	70	6.878 ± 0.224
	80	0.099 ± 0.016
	90	13.85 ± 0.55
LM	10	3.640 ± 0.199
	20	1.140 ± 0.058
	30	0.820 ± 0.047
	40	0.123 ± 0.020
	50	0.611 ± 0.044
	60	1.038 ± 0.051
	70	3.870 ± 0.213
	80	1.724 ± 0.081
	90	0.548 ± 0.047
HI	130	115 ± 7
	140	104 ± 5
	150	24.47 ± 1.15
	160	22.21 ± 1.08
	170	27.97 ± 1.10
	180	1.311 ± 0.051
	190	1.801 ± 0.069
	200	0.635 ± 0.048

TABLE B-II

SOIL SAMPLE RESULTS

IDR AIR SUPPORT STRUCTURE

1974

PLUTONIUM-239 AND -240

Location	Result (dpm Per Gram of Soil)
Center, East Side	2.806 ± 0.147
Center, West Side	0.459 ± 0.040
10 ft South of SW Corner (External)	2.330 ± 0.087
10 ft South of SE Corner (External)	0.270 ± 0.028
10 ft North of NW Corner (External)	5.497 ± 0.200
10 ft North of NE Corner (External)	2.756 ± 0.101
50 ft Dia SE of NW Corner	0.419 ± 0.039
50 ft Dia NW of SE Corner	1.382 ± 0.056
50 ft Dia NE of SW Corner	29.00 ± 1.26
50 ft Dia SW of NE Corner	2.750 ± 0.121

TABLE B-III

SOIL SAMPLE

QUALITY CONTROL CHECKS

1974

PLUTONIUM-239

HSL Standard No.	HSL Value[a]	Commercial Lab Result[a]
12-31-1	blank	0.046 ± 0.010
12-31-2	0.901 ± 0.003	0.871 ± 0.045
12-31-3	20.13 ± 0.07	16.28 ± 0.90
12-31-4	8.98 ± 0.06	7.312 ± 0.311

[a] dpm per gram of soil.

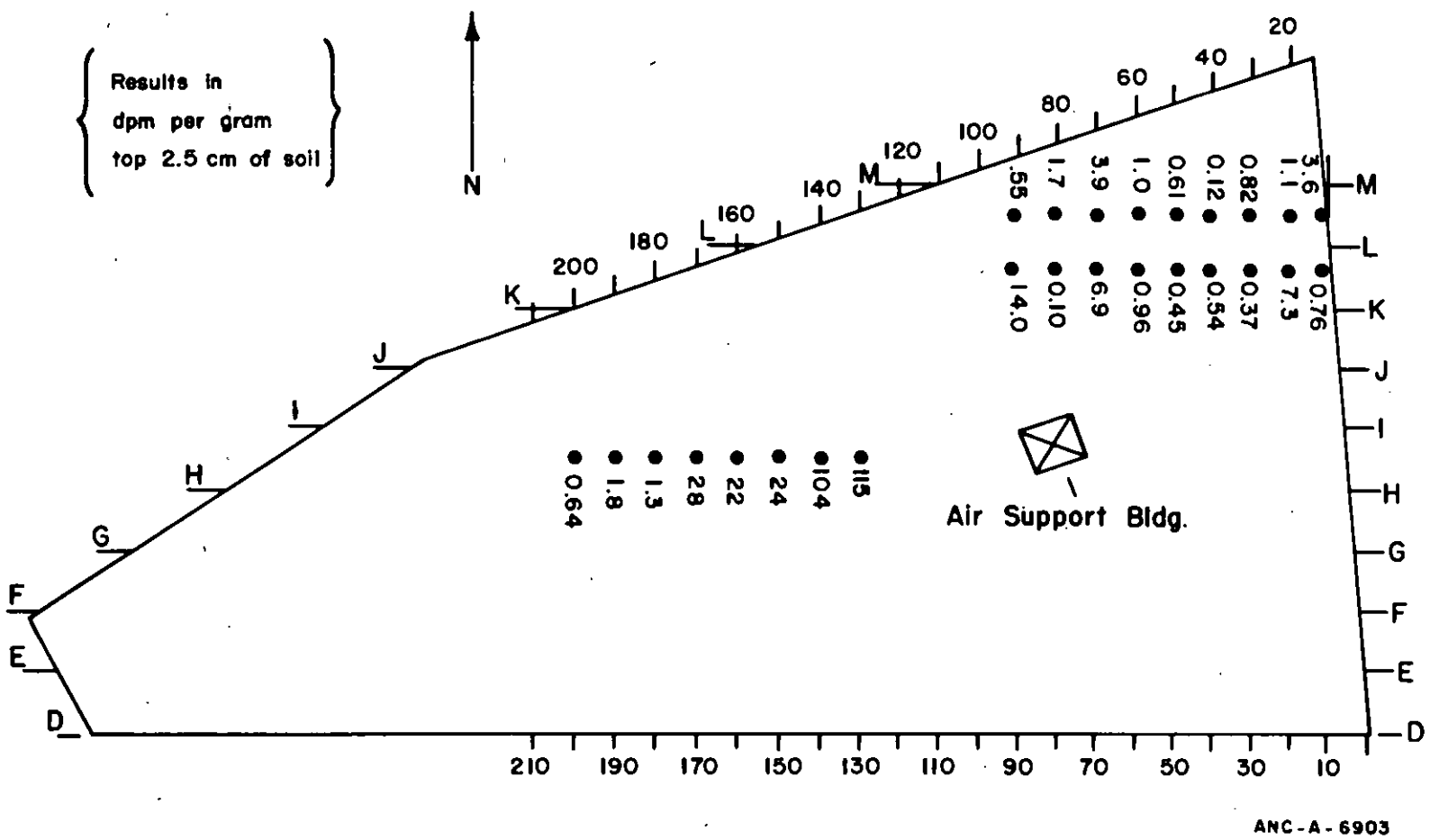

Fig. B-1 Pu-239 in surface soil of the RWMC 1974.

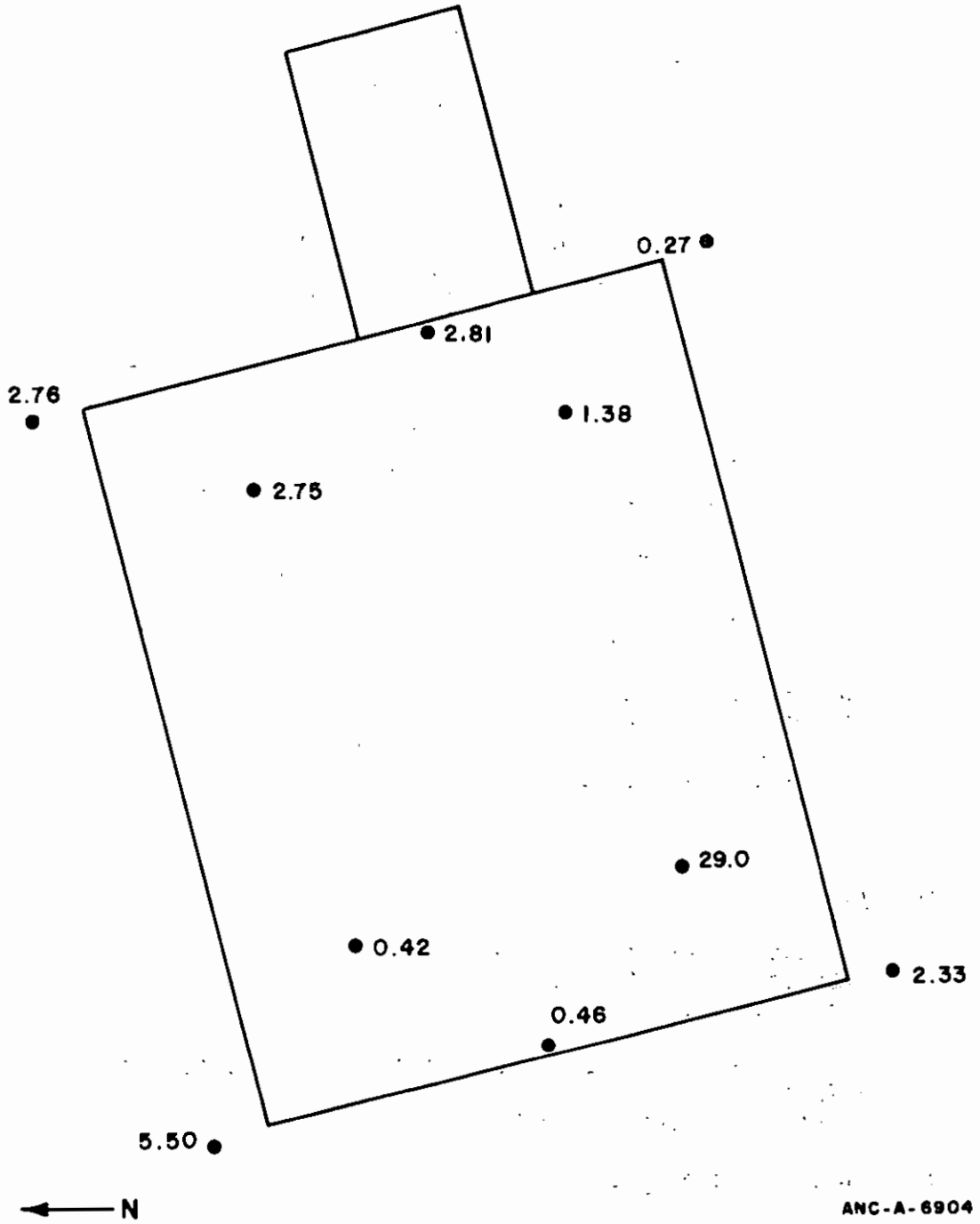

Fig. B-2 Plutonium in surface soil IDR air support building.

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